smallest on these streams was 7.6 mm. alt. by 15 diameter; the largest was 20 mm. in diameter. One colony had fine albinos.

MIGRATION OF ILYANASSA OBSOLETA, LITORINA LITOREA AND LITORINA RUDIS.

BY C. H. BATCHELDER.

The migration of a species is an important event in the history of a brackish water stream. It marks at once, the departure of somebody's food and the passing of *somebody else's* enemy; it means that the biological relations of the remaining species will be upset and that readjustment must take place. With the passing of an enemy, a species that has lived in seclusion prospers, multiplies and assumes other abodes previously inacessible. In new situations new foods become available,—and so things change. The snails of a brackish-water stream are as subject to annual migrations as the other inhabitants and some of them are extremely interesting to observe. Migrations of *Nassa obsoleta, L. litorea and L. rudis* were observed on Oyster river, Durham, N. H. in 1914–15 and the following is an account of the movements.

The most notable molluscan migrations that I have observed are the annual movements of *Ilyanassa obsoleta.* During late spring, summer and early fall it inhabits the mud flats exposed at low-tide. This environment becomes impossible, however, during the colder months when ground-ice may form and this forces the snail to migrate to the deeper waters for the winter.

Migration of Ilyanassa downstream was first observed on the 18th of October in 1914 and it had probably proceeded then during five or six days. Migration continued during the next two weeks but the greater number of healthier individuals moved down-stream in the week ending October 25. The rate of their movement appeared to depend somewhat on the temperature but no measurements were taken in support of this. The healthy individuals moved out into the deep water of the channel to depths varying from ten to fifteen feet at low tide.

This meant a journey of from five to fifty yards and some of them may have gone farther. After deep water is reached the operculum is not drawn entirely over the foot but just sufficiently so to permit the gray, wrinkled flesh to protrude all around the operculum and just level with the aperture of the shell. This is the condition of hibernation for the winter. This was evidenced by examination of all stations in February 1915 when the dormant condition was found to be characteristic even for the older and weaker individuals who had completely lost their opercula. Some of the feebler individuals were unable to reach the deeper water and stopped where the water always runs in a swift current. Here, they bedded in pockets to the number of several hundreds. A few were discovered in the mud-flat channel where there is an inch of water at the lowest tides but these always present the appearance of extreme old age.

Migration of Ilyanassa upstream began on either April 6th or 7th and continued during the following two weeks, the more vigorous of the migrants proceeding upstream in the interval between April 8 and 15. Showers fell during the 5th and 6th which warmed the water and reduced its density. Crawling steadily they reached their summer habitat in four days. At this time their distribution on low-tide flats was very characteristic. A dozen snails picked up at random would include smaller, older and more eroded individuals than would be the case if the lot had come from the channel. Evidently, these snails were the last to migrate in the fall. They were followed by a larger lot with spires worn very little, opercula unbroken and with a more brilliant cuticle. These spread out over the flats and intermingled with the cripples already in possession. This difference in the general average was quite perceptible in the first stages of the migration but was soon obliterated. An economic distribution of the species is probably never accomplished and adjustment is probably not attained before the summer. Even in summer Ilyanassa roves about a great deal on the mud flats and they may always be found in the channels in small numbers.

The migrating Ilyanassa are very interesting to watch. At times the channel bottom is purple with the migrating snails. Each one will be seen to be poking his siphon out an inch ahead of him testing the water to the right and to the left and always moving along with a characteristic persistency. He only stops where the current has swept everything else away and then only until the tide favors him again. I have seen, him crawling along where the crabs were hanging on to the sea weeds for dear life, and even while stopped for a while one sees him still testing the water ahead of him. He eats his lunch on the march, troubles himself not at all about his shelter for the night but ploughs his way along even though the water in his path be fresh, opaque with sediment or a briny salt pool. It matters nothing to him : over the obstacles in his path he crawls, reaches the channel bank and then seeks out a new environment in the water below or if it be in spring on the mud flats above.

One more interesting habit of Ilyanassa and we shall be done with him. He is not always submarine in his habits. While traveling over the surface he must have water running over him. He stops wherever the tide uncovers him. When the tide comes in again it may find him perched on a rock. This approach of the water may loosen his hold and he may tip backward curling in his foot as he tumbles. Many times he simply rolls over and is submerged ; but as often the current catches him and bears him along upside down with his inturned foot preserving the buoyancy of the mass. I have seen dozens floating along in just this manner, but whether it is an accident or purposeful activity, I have been unable to find out. Sometimes he steals a ride on the back of his neighbor, or on a floating weed or stick and quite often on the shell of *L. litorea.*

Litorina litorea migrates with Ilyanassa but is far less active. They move very slowly, rest frequently and often explore the rocks and ledges that line the channel. They follow Ilyanassa down stream in the fall part way, winter with them in the shallower, ice-free basins and return with them in the spring. During the winter *L. litorea* may be found clinging fast to the rocks in the channel bed or may go no farther than the lowest of the shore bowlders where they hibernate with *L. rudis* under the Fucus hovers. They migrate at most 25 or 30 feet.

Litorina rudis and *L. pulliata* are two other inhabitants of the brackish waters which must migrate annually to escape the ground ice of winter. These forms inhabit the Fucus fronds and rocks along the shore between tides. They do not leave these situations until driven out by the cold. Hence, they do not leave their stations until the middle of November and then move very slowly down over the Fucus and rocks to some point below the level of ice formation. In February they are most frequently discovered beneath the lowest living fronds of Fucus which hang down over the lowest line of exposed bowlders forming a hover for the snails. They may also be found packed into the crevices between the rocks and under the over-hanging ledges. The larger snails apparently lead an active life during the severest winter weather, for I have found them still feeding at 12° C. I have also discovered them in active copulation in every month of the winter. The younger individuals are less fortunate in their migration. Apparently they become exhausted and crawl beneath the stones of the upper tide limits where they hibernate during the winter months. They are the first of the snails to appear, however, coming forth this year during the week of March 1st. Active migration of the larger snail did not begin until the fourteenth of the month and the upper limits were reached on the twenty-first of March. The migration continued for some time later though less perceptibly and less actively.

I have not observed any one cause for the migration of these snails except temperature. The Ilyanassa offers a perplexing problem indeed. If it isn't absolutely necessary, why do they go into very deep water? They leave the flats and return when the water at low tide is at or near 13.5° C. *L. litorea* apparently wanders about until by pure accident he stumbles onto a place favorable for hibernation. *L. rudis* and *palliata* migrated most actively when the temperature of the water at high tide was 11.5° C. Density changes in the water were so slight that they cannot be held responsible for the migrations. A shortage of food material may be important; but the causes, whatever they are, seem complex enough for a special study of the subject.